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Coordination of Theory and Practice in Plow Design and Operation*

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THE published literature on plow design, and the hitch, especially with relation to tractor plows, is meagre. A few figures will, however, attract attention to the desirability of concentration upon the above subject with a view to analyzing the basic features of successful operation, as well as design.

The Department of Agriculture indicates in its statistics the fact that there are about 360 million acres of land under cultivation in the United States at this time, seventy per cent of which figures can safely be used to designate the amount of land yearly turned over with a plow or equally effective implement using approximately the same power.

On the basis of an average pull of 550 pounds per 14-inch bottom and 4 inches deep, at a speed of 2½ miles per hour, the rough energy expenditure would amount to better than 2,668,050,000 horsepower hours per annum consumed in this one operation. In view of this fact are we doing all we can to reduce this energy expenditure to a sensible minimum? Have we analyzed the plow, the hitch, the tractor, the horse or other power to the extent possible and given the farmer the benefit of these deductions? Can we save him money on this amount? If one per cent can be saved it is calculated, on the basis of $2.75 per acre, that this saving would amount to nearly $6,930,000 a year. How much more than one per cent can be saved? Every needless energy loss is accompanied by a corresponding material loss, since energy loss reflects itself in the repair bill which will add considerably to the above named figures.

With an idea of showing what can be done, this paper is prepared placing special concentration on that elusive feature—the correct hitch. There are numerous factors to consider, each with its range of variables, but we shall assume a set of average data for emphasis.

Some argument might arise as to whether the modern method of turning over the soil with a standard moldboard plow is the ultimate or most logical. This cannot be definitely answered now, but for years to come this method will prevail because of the fact that in our present knowledge of the art it takes the minimum amount of energy to accomplish this given result, and such devices and methods which up to date have been substituted for the present plow, have unfortunately fallen to ground under this yearly task.

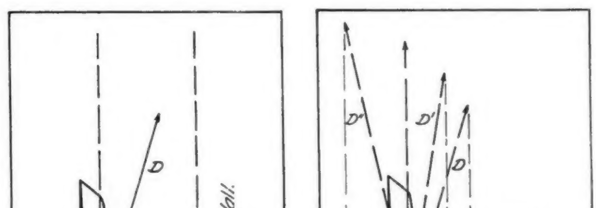
Perhaps this analysis will attract more careful study from new angles, and we may develop further ideas which will work out to success. While this analysis will carry us through an apparent maze of detail, it is hoped that the conclusions set up at the end of this paper, with their supporting technical argument, will be found practically useful.

With this foreword let us review the plow from the simple single unit to its combinations, operations and accessories.

Considering the single bottom (Fig. 1), and analyzing the complicated series of forces acting on this outfit, we readily see it is desirable to resolve all forces into three, whose center, (*O*) on the moldboard we shall have to assume as that point which is the result of judgment until it can be more definitely located by experiment.[1]

1. The Principal Vertical Forces. (a) That due to weight of the plow; (b) that due to the downward pressure

[1]This point is described by one authority as 2 inches up from the furrow sole, 3 inches from the furrow wall and 12 to 15 inches from the share point. By another the corresponding data is 2½ inches up, 2 inches over and 13 inches back.



At left, Fig. 1, and at right, Fig. 2, illustrating forces acting on plow bottom around assumed point O

*Paper presented at the fifteenth annual meeting of the American Society of Agricultural Engineers, Chicago, December 27, 28 and 29, 1921.

exerted during the lifting of the soil; (c) the lifting component due to the hitch being above the point of resistance, and (d) that force developed when the plow is dull and worn and which has the upward component the result of the sloping under surface of the share.

2. The Principal Horizontal Cross Furrow Forces. (a) Due to the cross component caused by the friction of the soil on the moldboard, and (b) by the transferring of the soil sideways the width of the furrow; (c) the cross component due to the cutting and wedging edge of the sloping share edge in operation; (d) the component of the line of draft, and (e) such cross component as may result from rear or furrow wheel reactions in multiple outfits, where used.

3. The Principal Longitudinal Forces Acting Lengthwise of the Furrow. (a) The soil resistance to cutting; (b) the friction between the furrow wall and the landside; (c) the friction due to the weight and pressure on the bottom of the plow according to the setting or condition of the cutting wedge; (d) the component of friction of the earth sliding over the moldboard. For equilibrium then we have the sum resultant forces of W, R, and P, counteracted by D, the draft produced by the motive power.

It is then for us as engineers to see what can be done to reduce the necessary force D to a minimum by every sensible means and still retain good working conditions.

In the multiple plow outfit we carry the largest part of the weight on wheels in order to change the sliding friction of the simple plow into rolling friction; we choose our materials and model the shape to minimize the sliding friction as far as possible, and heat treat the parts to maintain the life of the plow against erosion to a satisfactory degree; we provide the shape and material such that necessary repairing and sharpening may be accomplished with facility; we provide means for arranging the hitch over a range of vertical and horizontal adjustments to care for the varying conditions of soil resistance, speed, nature of motive power, etc. It is clear that in the tractor plows the composite force (W) is generally carried on the three wheels, so for the moment we may delay considering this factor and concern ourselves with the forces in the horizontal plane.

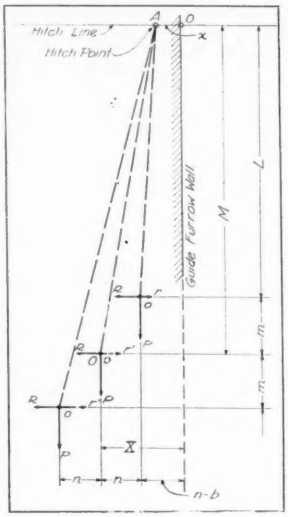
The moldboard being a modified warped surface as analyzed in a paper by Dr. E. A. White [2], when it acts upon the soil creates the side pressure R against the landside, which, if not relieved by pulling or pushing the outfit, in a direction to counteract this force, will create a friction in excess of that necessary, in the magnitude of Rf, where f is the coefficient of friction between earth and steel; values of which are noted in Table I, which data this Society must revise and extend for future reference.

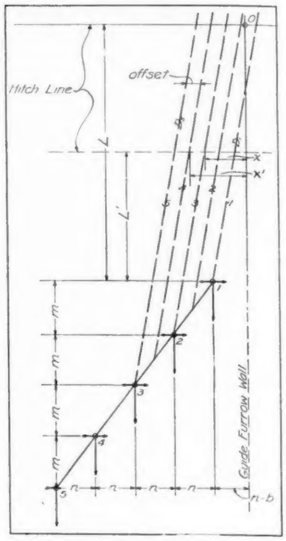
Judging from this and scouring conditions of moist and wet soils, we can assume that the coefficients of friction, earth to steel, run approximately over this same range. This data will have to serve our purpose until experimental data will give us definite facts.

TABLE 1—VALUES OF COEFFICIENT OF FRICTION

	Coef. of Friction	Angle of Repose in Degrees
Earth on earth	.25-1.00	14.0-45.0
Earth on earth, dry sand, clay and mixed earth	.38- .75	21.0-37.0
Earth on earth, damp clay	1.00	45.0
Earth on earth, wet clay	.31	17.0
Earth on earth, shingle and gravel	.81-1.11	39.0-48.0

[2] A study of the Plow Bottom and its Action Upon the Furrow Slice, Journal of Agricultural Research, Vol. XII, No. 4, Government Printing Office, Washington, D. C.





Figs. 3 and 4, at left and right, illustrating horizontal angle and lateral adjustment of hitch

The general equations of horizontal forces then follows:

$D=\sqrt{[P+f\ (R-r)]^2+r^2}$
$D\ \cos a=r$
D=drawbar pull
P=resistance lengthwise of furrow
R=cross furrow reaction to left
r=cross furrow reaction to right, or left
f=coefficient of friction, steel to earth

Or, we can say that when $D \cos a = r=R$, and is acting in opposition, there will be no landside pressure and $(R-r)\ f=O$; hence, $D=\sqrt{P^2+R^2}$. This equation, then, would furnish the actual pull in the horizontal plane and through the center of reaction of all horizontal forces on O and in the direction of D. The strain in the line of D for any other angle from the horizontal would be $D \div \cos B$ when B=angle of draft with the horizontal plane, the vertical component of which would counteract the load W in part.

It is certain that if we hitch to the right of O, (Fig. 2) or toward the guide furrow wall to a degree such that $D \cos a$, or r, is equal to or greater than R, the plow will tend to run out onto the plowed land and likewise if we lead away from the guide furrow wall so that angle a is greater than 90 degrees, we automatically increase the pressure still further against the furrow wall, R, until a point is reached where the plows will run into the land due to a crushing down of the furrow wall receiving this pressure. These two extremes then give us the limits of possible practical operation on level ground. Obviously we desire to maintain, for steady operation, a component toward the unplowed land either as a reasonable pressure against the furrow wall, through the landslide, or by means of the rear or furrow carrier wheel, the sensible amount of which pressure we shall have to determine by experiment.

The tractor plow consisting of from two bottoms up to any desired number is, naturally, a multiple problem of the single bottom. Taking a three-bottom outfit for illustration, we reason as follows:

Assume the tractor hitch point at A (Fig. 3) a distance from the guide furrow wall equal to x. The distance (L) to the first bottom and P, R, and r, acting at the assumed point (o) of composite forces O, a distance b from the landside of any individual plow.

The three lines joining the plow bottoms to the hitch point are at different angles, hence the relief of landside pressure would be different for each plow bottom if these were not rigidly connected together. To find this combined effect we can analyze it by taking moments about any point as O (Fig. 3), the intersection of the guide furrow wall and the hitch line, thus:

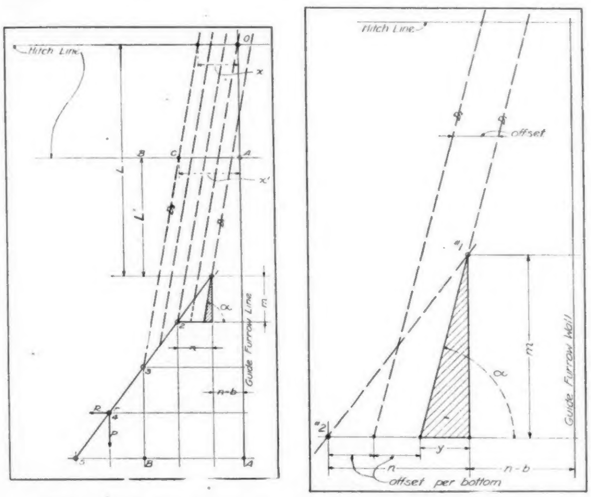
$$P(n\text{-}b)+P(2n\text{-}b)+P(3n\text{-}b)= 3PX$$
$$6\,Pn-3bP=3PX$$
$$2n-b=X$$

Also the center of action from the hitch line

$$RL+R\ (L+m)+R(L+2m)=3RM$$
$$3RL+3Rm=3RM, \text{ or } L+m=M$$

Where M=the distance from hitch line to center O of plow outfit, which proves that the combined center of reaction of a three-bottom gang lies on plow No. 2 and at its center of reaction O. By deduction we can place the *center of reaction of any number of bottoms instantly as the midpoint on the line of center of reaction of the individual plows.*

What now interests us practically is the answer to the question of where to hitch on the motive power to meet the



Figs. 5 and 6, left and right respectfully, analysis of hitch with exaggerated angle for clearance

variety of conditions of the various soil resistances, moisture content, types of bottoms, length of hitch, condition of plows, etc. The basis, however, can be much aided by this analysis.

Whether it be one bottom or many, the theoretically correct line of draft in a given soil with conditions all alike, gives us a constant direction of the draft line D (Fig. 4), acting through the combined center of reaction, i. e., for one bottom we have Line 1; for two bottoms, Line 2, etc., all of which lines cross any given line (as through O) at equal distances, and hence the distance we are interested in, x or x', is the theoretical hitch point distance from the guide furrow wall. This obviously is different for every variable length of L, or L', and every different number of bottoms, and varies also with every given size and type of bottom, nature and condition of soil. The shorter the length L, the farther we can hitch from the furrow wall, providing, of course, that this close hitch does not interfere with good operating and turning. Under these conditions we would have the same general reactions provided the same angle in the vertical plane is maintained with respect to the ground.

We are now in a position to develop the general formula, to cover any number of plows, any length of hitch, any width of cut or any spacing lengthwise of the furrow of the several bottoms, and determine the distance from the furrow wall to hitch to and have *no pressure* on the furrow wall. From this calculation we can arrange to secure what is desired in the way of furrow wall pressure, or an equivalent reaction taken by the rear or other carrier wheel.

Figs. 5 and 6 represent the conditions with an exaggerated angle a to facilitate the understanding. It is clear that as we add each plow we must offset from the furrow wall a definite amount according to the relation of the actual R against the furrow wall when pulling parallel with the furrow, and P, the draft lengthwise of the furrow without the added component of friction, such that $cot\ a = R \div P$ which determines for no landside pressure the direction of D_1 to D_5. In Fig. 6, then, the offset between these lines may be found as $(n - y) \div 2$, or $y = m\ cot\ a$, hence the offset $= (n - m\ cot\ a) \div 2$

Refer to Fig. 5 and follow through the total offset from the furrow wall x or x' as being $x = AB - BC = (n - b) + (N - 1)\ (n - m\ cot\ a) \div 2 - L'\ cot\ a$

in which n = width of furrow cut

- b = distance from furrow wall to composite O of action
- N = number of plows in action
- m = spacing of plows lengthwise of furrow
- a = angle of D with respect to cross furrow line
- L' = distance from first plow center of reaction to the pitch line

As the foregoing hitches are drawn with D as though consisting of a single line we have to substitute therefor the rigid or chain hitch of various forms.

In every case for proper operation the imaginary line DD is fixed, and modification of the single line hitch must balance about said line as indicated. The proof is simple by mechanics or graphics. This chain hitch is very useful when operating with plows having large numbers of bottoms.

Should the chain be continuous and pass over pulleys at the four corners as in the above third illustration, instead of a locked condition, it is obvious that no relief can be exerted for the cross-furrow force, hence the draft must be greater than in the first two. However, should this cross chain and pulley combination have been substituted for a hitch, which had acted on the tractor to the left of a line joining the center of reaction O and parallel to the furrow wall, relief would result, but not if the tractor hitch had been to the right of said line.

In these diagrams (Fig. 7) CD equals DE either side of the direction line D, and at the respective ends.

From practical results let us take the judgment of experienced plow operators as recommended to this Society for standardized hitch data and see how the X values stand.

TABLE 2—RECOMMENDED STANDARDIZED HITCHES

(A.S.A.E.) (S.A.E.)

14″ bottoms: b = 2″, L = 80′, m = 19″, n = 14″

No. of Plows	Distance from Furrow Wall OX: OX Min.	OX Max.	Center	Calculated from Rear: Off Center R	Off Center L	L′ & M
2	15″	30″	20″	4.5″—3° 1′	10.5″—6° 42′	89.5″
3	20″	32″	26″	6″ —3° 28′	6″ —3° 28′	99″
4	24″	40″	32″	8″ —4° 13′	8″ —4° 13′	108.5″

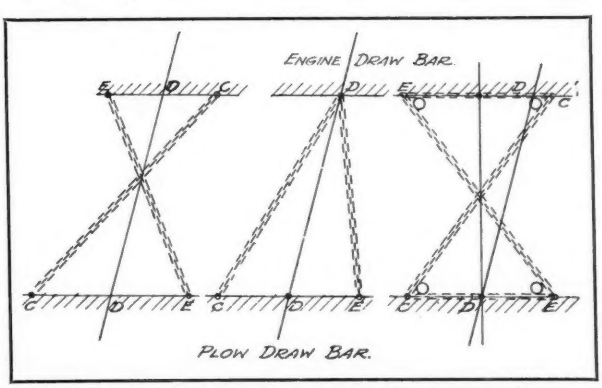


Fig. 7. Application of theoretical lines of draft to various types of chain plow hitch

The off center distances are shown right and left of a given line, like P, passing through the center of plow reactions and are read at the tractor hitch point. The distance from said reaction to the hitch line is equal to L and M.

As a practical example emphasizes readily the features desirable to drive home, we will take the case of the three-bottom outfit and calculate the ideal hitch in light and heavy land and show what modifications have to be made to coordinate with the theory advanced above, as well as these recommendations.

From Table 2 we find 6 inches advocated as the limits of center distances and 99 inches as the designed length $(L' + M)$ from the hitch point to the center of reaction. If force D pulls along a line 6 inches off center and 99 inches long, the cross furrow effect of D would be in relation to P, as $1: 16.5 = P: r$.

As the recommended minimum and maximum values of hitch from the furrow wall are 20 inches and 32 inches and are dependent on loose or light soil conditions, we wish to deduct the corresponding effects in heavy soil on the proper hitch point. The ratio of 1: 16.5 in various soils then give us the following:

TABLE 3—Soil Resistances P and Reactions per Bottom

P:R = 1:8. Angle of D — 6" to right of center of reaction. Hitch 99" from center of plow reactions.
r = D cos a = P cot (90° — x) 3° 28'. P:r = 1:16.5

P lbs.	R lbs.	r lbs.	(R-r) lbs.	Soil	*f* (*R-r*) f=.30 lbs.	f=1.60
400	50	24.2	25.8	Very light	7.84	25.8
600	75	36.4	37.6		10.28	3 .6
800	100	48.5	51.5	Medium	15.45	51.5
1000	125	60.6	64.4		19.32	64.4
1200	150	72.7	77.3	Heavy	23.19	77.3
1400	175	84.8	90.2		27.06	90.2
1600	200	97.0	103.0		30.90	103.0
1800	225	109.0	116.0	Very heavy	34.80	116.0

The first inspection of these figures emphasizes the feature that with a given type of plow bottom, operating in various soils the same theoretical hitch gives needlessly high pressures of $(R - r)$ in all but light soils. If 25.8 pounds will hold the plow against the furrow wall, 116 pounds is not necessary in heavier soils. We can then conclude that roughly 25 pounds per bottom should do for all, and we can relieve the balance of the reaction by decreasing the angle a or increasing the angle $(90 - a)$. What we want then is a net reaction $(R - r) = 25$ pounds all through. Here we have the calculation to determine the change in angle of pull to secure this:

$$\frac{R - r}{P + f\,(R - r)} = \tan\,(90 - a)$$

Case 1. Soil resistance 400 pounds, $P: (R - r) = 1:16.5$
Type of moldboard such that $P{:}R = 1{:}8$
$50{:}400{::}\ 1{:}8$ and the soil friction $f = 0.3$
If now we pull to the right until $R - r = 25$ pounds and solve the equation above we have:

$$\frac{25}{400 \times 0.30\,(50 - 25)} = \frac{25}{407.5} = \tan\,(90 - a) = .0614.$$

Therefore $(90 - a) = 3°\ 31' = 6\tfrac{1}{8}$ inches offset to the right of center line which figure agrees very closely with that advocated.

Case 2. Soil resistance 1800 pounds, $P' : R' - r' = 1:16.5$
$P : r = 1 : 8$ with same moldboard as above, but the frictional resistance of this heavy soil we assume as $f' = 1$.
If again we pull to the right until $(R' - r') = 25$ and solve the equation, we have: $P' : R' :: 1800: 225$

$$\frac{25}{1800 + 1.0\,(225 - 200)} = \frac{25}{1825} = \tan\,(90 - a) = .1101$$

and $(90 - a) = 6° = 17$ inches $= 11\tfrac{1}{8}$ inches to the right of center line. The center of reaction is $(n - b) + n$ from the furrow wall for three bottoms $= 14 - 2 + 14 = 26$ inches, from which we deduce

$26 - 6\tfrac{1}{8} = 19\tfrac{7}{8}$ inches $= X$ for ***light soil*** from the furrow wall

$26 - 11\tfrac{1}{8} = 14\tfrac{7}{8}$ inches $= X$ for ***heavy soil*** from the furrow wall

This gives us the same pressure against the furrow for light and heavy soil, and minimizes the draft D and landside friction to that which will give good operation.

It should be more clearly seen now that when we apply the first formula developed $D = \sqrt{[(P + f\,(R - r)]^2 + r^2}$ and make $r = R$, no landside pressure develops, solving results in a draft $D = \sqrt{P^2 + r^2} = 1814$ pounds

For the 25 pound landside pressure we have

$D' = \sqrt{[1800 + 1.00\,(225 - 200)]^2 + 200^2} = 1836$ pounds, or 1.2 per cent increase.

For pulling straight ahead we get no relief as $r = O$.

$D'' = \sqrt{(1800 + 1.00 \times 225)^2} = 2025$ pounds, or 11 + per cent increase.

Next by pulling 3 degrees 31 minutes, or 6 inches to the *left* of center we get

$D''' = \sqrt{[1800 + 1.00\,(225 + 109\,)]^2 + 109^2} = 2136$ pounds, or 17.7 per cent increase.

If we still further assume that the furrow wall will stand up against the force of net R up to the 6° 17' angle to the left of center which means a hitch $26 + 11\tfrac{1}{8} = 37\tfrac{1}{8}$ inches from the furrow wall

$D'''' = \sqrt{1800 + 1.0\,(225 + 202)^2} = 2235$ pounds, or 23.2 per cent.

This discussion is on the assumption that the rear carrier wheel does not resist the cross furrow pressure. It can do so completely up to the point of pulling straight ahead of the center of plow reaction or up to a hitch 26 inches from the furrow wall for the three-plow outfit if it is so designed as to lock and resist side pressure, thus taking the thrust instead of its going to the landside, changing sliding friction to rolling friction, but it will not relieve landside pressure if the wheel is free to swing with plows in the ground acting only as a weight carrier. From the above it should not be wondered at that the same plows in the same land, at the same depth, in the same conditions, and operated at the same speed, show different drawbar pulls.

Varying hitch points relatively right and left would explain much of these differences. Other shapes of moldboards would either decrease or increase the percentages in accordance with the designed ratios of $P : R$, being different from 1 : 8, as assumed from this example.

Again if the speed is increased we readily see that the net R changes in a different ratio than the other several components, and a plow which at two miles per hour would be a 1 : 8 ratio, might be at three miles a 1: 6 ratio.

Attention to the recording of data covering hitch points from the furrow wall the distance from hitch point to center of reaction, the heights of hitch, the type of moldboard, and cross furrow forces should therefore appear as part of tractor trial field data just as much as speed of plowing, drawbar pull and fuel consumed per acre.

The vertical reactions next need attention from the standpoint of the hitch. Fig. 8 will serve to illustrate the rough relations which exist on a type of plow operating at 6 inches deep.

The weight, carried on three points as on wheels, A, B, C, will vary between the condition of simply hauling the out-

fit over ground to that produced by the plows being in action and lifting and turning the soil.

TABLE 4—LOADS ON THREE BOTTOM PLOWS
SOIL AT 90 LBS. PER CU. FT.

Wheel Loads	A Furrow Wheel lbs.	B Lard Wheel lbs.	C Rear Wheel lbs.	Total lbs.	Distribution of Soil Weight Pounds			Total lbs.
Light overland	360	336	367	1063	F.W.	L.W.	R.W.	0.0
Pl. 3" deep	412.2	397.6	469.6	1279	52.2	61.6	102.6	216.4
Pl. 6" deep	464.3	459.2	572.2	1496	104.3	123.2	205.2	432.7
Pl. 9" deep	516.5	525.8	674.8	1717	156.5	184.8	307.8	649.1

Table 4 illustrates the pure loads without the entry of the vertical component, resulting from the hitch to the drawbar being above the center of reaction O, and the inertia effects of very rapid plowing.

Review of specific data placed the gravity center of the three plow outfit at approximately just ahead of the nose of No. 2 bottom and about 1¾ inches to the right of the landside, viewed from the rear, also about 16 inches above the bottom of the furrow when set to plow 6 inches deep.

The simplest method of obtaining the center of gravity being to balance the outfit over angle bars, set first cross furrow then lengthwise of the furrow. The height of the center of gravity being determined by hanging up the plow and finding the gravity center by means of a plumb line projection onto two views.

The gravity center may also be calculated by taking equivalent moments of line A about the line BC, B about the line AC, and C about the line AB, each with respect to the total load W about the same lines.

Wheel B or A used to operate the power lift must have traction enough to withstand the drag of this operation, and also take care of the cross furrow reaction which may be transferred to it through the incorrect hitch, hence the necessary weight or other device to increase traction on this rim.

The rear carrier wheel running on newly cut ground must bear the necessary load so that its load multiplied by the coefficient of friction of steel to earth will still be safe against the side thrust of the three bottoms.

The reaction being W at $C \times f = 3$ times the net R per bottom. In Table 4 three bottoms 6 inches deep we see rear wheel load = 572.2 pounds, $f = 1.0$, and $(R - r)$ we shall take at its most, 116 pounds. Then 572.2 pounds is greater than 348 pounds. But if $f = 0.3$ we would have $572.2 \times 0.3 = 171.7$ pounds which is less than $3 \times 116 = 348$, hence the rear wheel would slip and be ineffective allowing the landside to carry the reaction net R. Under these conditions the rear wheel need not necessarily hug the corner of the furrow, in the first case, but would better do so in the second.

Again, our hitch between the rigid bar or chain and the plow drawbar may affect this materially, as shown in Fig. 8. The adjustment enables us to alter the hitch point, at both drawbars, above and below a straight line between motive power hitch and plow hitch. If the plow hitch be above the imaginary line we will lift part of the weight from the wheel C and transfer it to A and B, the whole outfit tending to rock about a line through the earth contact points of wheels A and B.

On the other hand, if the line runs low on the plow hitch bar the tendency is to lift the load from the wheels A and B and transfer it to C. Correction of this feature is however, more understandable than the side reactions, and less operation trouble is experienced in the field with it.

The chief cause of unsatisfactory draft which affects the vertical forces is that of dull shares.

With a properly set and adjusted plow outfit our downward forces are primarily the total load on the wheels plus the load of earth being carried. This is partly overcome by the upward pull or vertical component of D, but our net W is down and is carried entirely by rolling friction because the plow is so built that only the cutting edge is in contact with the bottom of the furrow.

As the shares become dull they, however, soon form a surface beneath sufficient to present an area and our draft increases because this dull wedge tends to lift and change part of the rolling friction load to sliding friction until at last the area and the furrow bottom present values which will carry the net weight of the whole outfit and our frictional

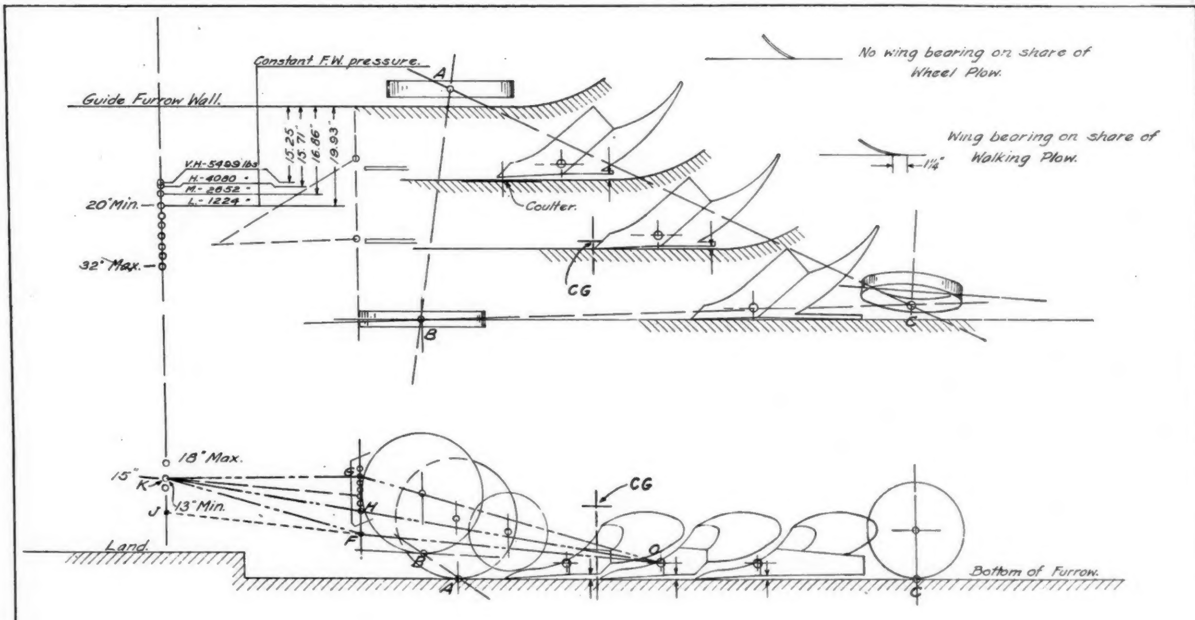


FIG-8

Fig. 8. Diagram showing rough relations, both horizontal and vertical, of a plow running six inches deep

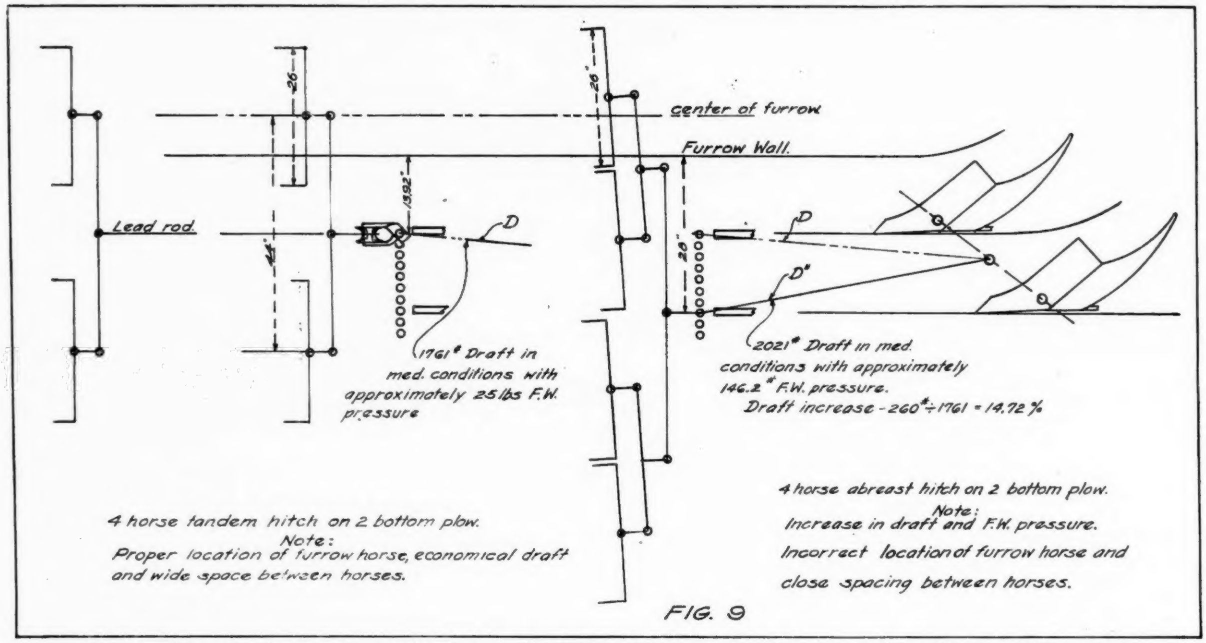


Fig. 9. The four-horse abreast hitch and the tandem hitch compared as to results with two-bottom plow

resistance Wf has reached its maximum. Where $f = 1.0$ as before, and with a plow weight of 1495.7 pounds (Table 4), the draft has increased nearly 500 pounds per bottom, if we could keep it in the ground at all. The efforts will be within the values given below.

TABLE 5—DULL SHARES.

P—per Bottom lbs.	f—1.0 lbs.	Percent Increase	f—0.3 lbs.	Percent Increase
400	500	125	150	37.5
800	500	62.5	150	18.75
1200	500	41.7	150	12.50
1600	500	31.2	150	9.37
2000	500	25.0	150	7.50

The highest percentage shown for light soil and the lowest result for heavy soil are undoubtedly exceptional if not impossible, but the table serves the purpose of emphasizing this feature pending actual investigation.

Fig. 9 has reference to hitching draft animals to two-bottom plows. Two types of hitches are illustrated, the four-horse abreast and four-horse tandem.

In the Central West the two-bottom 14-inch plow with four-horse abreast hitch is without doubt the most popular, while in the West and the Northwest the tandem hitch is universally used. These tandem hitches may take four, five, six, or even seven horses. The four-horse abreast hitch on two-bottom plows, especially one that is smaller than 14 inches and also on the single 16-inch plow where very often four horses are necessary, has always had the attention of the plow designer.

The center of draft in any four-horse abreast equalizer will naturally be central, and when one horse walking in the furrow pulls upon this singletree over the center of the furrow, the center of draft on the whole device is governed by the length of the evener; the length of this evener is governed by the space in which it is possible to operate four horses abreast.

In order to keep the center of draft on the equalizer as near as possible to the furrow, the singletrees are usually very short—26 inches, or not over 30 inches. The singletree centers are as close together as possible, but unfortunately this equalizer center on the four-horse abreast hitch with one horse in the furrow is too far from the furrow wall to make it possible to hitch to the most economical hitching point on the plow. For this reason lateral hitch adjustments toward the land far in excess of what they should be are provided and to offset the evils of this incorrect hitch the plow designer has provided certain other adjustments.

Realizing that there is excessive furrow wall pressure when hitching to the extreme left, the rear wheel is therefore set close to the corner of the furrow, the edge of the tire usually being located about ½ to ¾ inches to the left of the landside of the plow, thus always taking advantage of the rolling friction on this wheel, even though the operator may not properly adjust the control rod controlling the direction of travel of this wheel.

The front furrow wheel is provided with adjustment on the tongue for adjusting the direction of travel of this wheel toward the land to properly hold the front end of the plow up into the land.

All friction against the bottom of the plow is eliminated, especially on wheel plows, by presenting only the cutting edge of the share to the bottom of the furrow, the rear portion of the landsides always being carried above the bottom of the furrow approximately ½ inch to insure carrying the weight on the wheels and avoid unnecessary friction on the bottom side of the plow.

The tandem hitch usually has this draft center near the furrow for the reason that more of the animals are operated in or closer to the furrow. It is also possible to have more space between each animal which is a big advantage particularly in the warmer climates.

There must be considerable energy lost by operating four horses abreast, as draft animals cannot work to the best advantage when crowded together. The principal reason for using four horses abreast is to facilitate plowing in smaller fields surrounded by a fence, while in the Northwest where fences are seldom used the tandem hitch is no doubt the better draft device.

The following conclusions are derived from the foregoing discussion:

1. As the economical hitching point on all plows is nearer the furrow than generally assumed, we should locate our draft animals or motive power in such position in front of the plow that the center of draft will register as near as possi-

ble to the proper location of hitch on the plow.

2. Considering the tractor, we realize that the center of the tractor should be directly ahead of the center of load wherever practicable, although hitching to the right or left of the center of load to a certain extent can be done. However, the average width of small tractors pulling small plows does not permit us to use this center point on the tractor directly ahead of the proper hitching point on the plow, especially when the tractor is operated on the land. If not objectionable or necessary we can then overcome part of this difficulty by operating the tractor in the furrow, and then compromise still further by hitching on the tractor drawbar to the furrow side of tractor center.

A still further compromise may be necessary and can be made by adjusting the plow hitch to the left or away from the furrow wall, or its ideal point. It should further be remembered that inasmuch as the tractor is less sensitive to offside pulling than is the plow, the compromising should, as far as possible, be in favor of the desirable plow hitch point. Since most tractor plows have a rear wheel designed to take the side thrust there can be no serious objection to hitching within the limits recommended. Consequently, we find it desirable to support the recommendations of the several hitch points as given in Table 2.

It will be noticed that the recommendations for the extreme adjustment on the plow hitch away from the furrow seem in excess of what they should be, especially in a two-bottom outfit. We have made this recommendation for the reason that in many conditions the tractor cannot be operated in the furrow, and we believe if the adjustment is used within these limits no serious operating difficulties will arise, but so far as practicable adhere to the minimum distance from the furrow wall.

In extremely light, fluffy soils, it is not advisable to make use of the extreme narrow adjustment from the furrow wall. Any plow must have a sufficient amount of furrow wall pressure to hold it in line of travel. At the same time it is desirable to keep this furrow wall pressure as low as possible.

3. When using draft animals it is useless to state any positive location of hitch on the plow without considering the center of draft on the equalizer used.

One essential requirement is proper width of cut and usually the operator will resort to the lateral hitch adjustment to accomplish this without regard for the economical hitching point. It should be the aim of every operator to arrange his draft animals by means of a suitable equalizer to bring about a center of draft on this equalizer that will register as nearly as possible with the proper hitch on the plow, and in the event that he is compelled to use four animals abreast where the hitch on the plow is considerably to the left of the ideal, he should not overlook all other possible means provided in this plow for offsetting this evil, such as proper location and direction of travel of the front wheel and proper relief on the under side of the plow from the bottom of the furrow.

When using the tandem hitch the difficulties are the reverse of those when using the abreast hitch for the reason that a tandem hitch can be just as far from proper in one

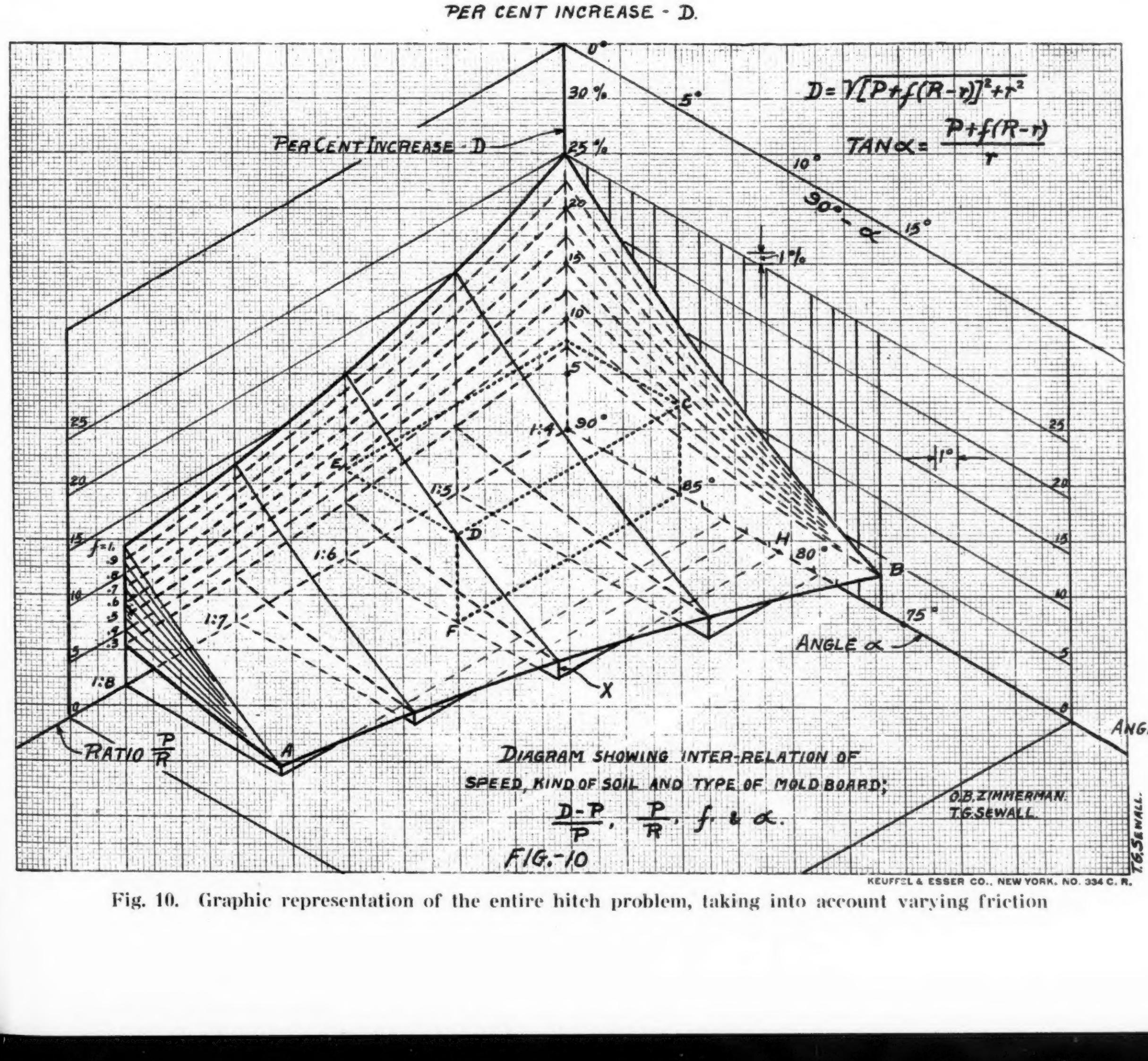


Fig. 10. Graphic representation of the entire hitch problem, taking into account varying friction

direction as the abreast hitch is in the other direction. There are conditions of light, fluffy soils where a narrow tandem hitch will bring about a hitching point on the plow too far to the right, thus dragging the plow sideways. In this condition the operator should spread the draft animals and thereby automatically move the center of draft more to the left to bring about a reasonable amount of furrow wall pressure that is necessary for successful operation.

4. For most economical plowing the operator should keep in mind reducing friction wherever possible. First, the cutting edge of the plow should be kept sharp and present only the cutting edge to the bottom of the furrow on wheel plows, in this way reducing all possible chance of bottom friction. Second, use sharp coulters not only to cut the trash but to separate the furrow slice from the land before it is turned by the plow. Third, where wheel adjustments are provided these adjustments should be made use of to control the direction of travel of these wheels. The rear wheel should lead slightly away from the furrow wall, and if hitching to the extreme left, such as when four animals are used abreast, the front wheel should lead slightly toward the land. If the wheel spindles are well lubricated this rolling friction may relieve considerable sliding friction. Fourth, the height of the hitch on the plow should be adjusted to distribute evenly the weight on the fore and aft carrying wheels, by adjusting downward at the clevis to relieve the load on the front wheel and increase the load on the rear wheel, or adjusting upward on the clevis to increase the load on the front wheels and decrease it on the rear wheel.

THE HITCH PROBLEM VISUALIZED

As we are interested in visualizing as much of the entire hitch problem covering as many variables and their interrelation as possible, Fig. 10 was constructed as a development of the formulae

$$D = \sqrt{[P + f(R - r)] + r^2}$$

$$Tan\ a = \frac{P + f(R - r)}{r}$$

We have here a space relation in which the three coordinates are:

1. The ratio $P : R$, or the relation of the down furrow force P to the cross furrow force R which exists at the moment under consideration when the plow is in operation and the various kinds of moldboards, those with long slope up to those very abrupt. While these ratios have been only roughly deduced from judgment and practical operation the diagram does not necessarily cover all but will serve a useful purpose.

2. The angles of pull of D between the center of plow reaction and the hitch point, with respect to either a cross furrow line like R, values of $a = 90$ to 75 degrees; or, as shown above, as the angle to the right of a down furrow line like P, as $(90 - a)$.

The effect of angles of pull to the left of the down furrow line or over 90 degrees can be roughly interpreted by imagining an extension of the warped planes through the left coordinate planes.

3. The percentage of increase of pull D over and above that needed is shown in percentages from 0 to 25. As the draft D is affected markedly by the coefficient of friction f, this feature is also incorporated.

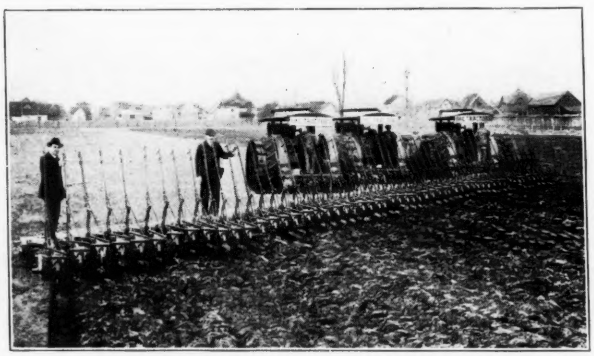
These relations form the surfaces shown as leaves of a book.

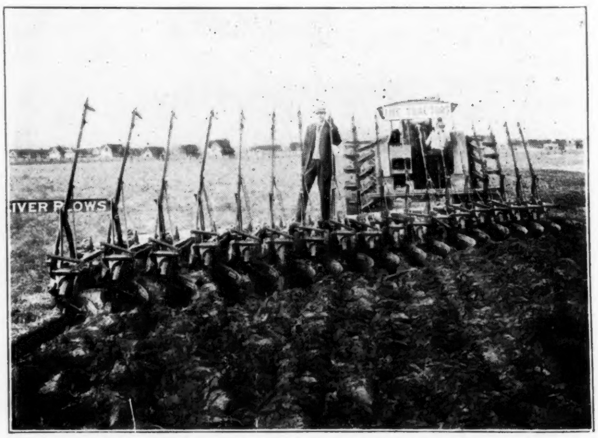
To interpret the diagram let us take one case, that of where we are hitching so as to have $a = 85$ degrees, or 5 degrees from the down furrow line and to the right. Run down line 85° to F, lying in the cross plane which represents $P : R$ as $6 : 1$, then rise until the line pierces the plane as at D where $f = 1$. Then $F\ D$, read on the per cent scale, shows 8 per cent. $8 - X = 8 - 1$, or 7 per cent net, greater draft for D with a hitch at 85 degrees than would be shown if our hitch had been set at H, or 81½ degrees, run out from X. At 81½ degrees the cross furrow force would be O; hence the practical angle would be somewhere between 81½ and 85 degrees, according to the desired furrow wall pressure and such other practical accommodation as is necessary.

A review of the diagram will clear up the values of these relations, when thinking relatively of light and heavy soil operation.

We can say then that as a plow is operating in a field of varying soil the draft D will vary with a given angle of hitch, passing, say, from plane $f = 1.$ to plane $f = 0.6$ back and forth. Also as the speed might vary causing the $P : R$ relation to go from $1 : 6$ to $1 : 5.5$ and if for any reason the angle of hitch should vary a few degrees due to hill slope plowing, say, between 4 to 7 degrees from the down furrow line, the draft would follow the corresponding relations according to the several coordinate values.

This emphasizes the desirability of our attempting to better establish the technical relations of $P : R$, which should be developed and the values of f which the Society should do, covering the typical soils tilled in the United States and the changes of f for the various moisture content. These are two real research problems in new plow design.





As proof of the above demonstration in a practical way, the two illustrations of large numbers of plows being pulled by one and three tractors will clearly show that the theory developed here applies when the cut of the plow is wider than the tracking of the tractor. These photographs were made in the days when "stunt" performances were carried out to emphasize the value of large tractor units, when in one case an acre was plowed in less than twelve minutes, and in the other in less than four minutes

The President's Annual Address*

By E. A. White

AGRICULTURAL engineering, "the art and science of engineering as applied to agriculture," is receiving an ever increasing recognition as one of the most potent, constructive and vital forces shaping the destiny of our agricultural developments. It has long been recognized that engineering developments are one of the chief characteristics which distinguish American agriculture from that of other nations, but the realization that these engineering forces may be logically grouped under one great standard, agricultural engineering, has been slow in coming, especially on the part of the general public. However, a rapid growth is not essential to the ultimate establishing of a fundamental fact in human society. It is far more important that progress in this direction be substantial rather than rapid. As was so ably elucidated by Ex-president Kranich in his address to you last year, our most notable achievement in the year 1920 was the recognition the Society obtained from various sources. It is a pleasure to report that due to the enthusiastic cooperation on the part of the officers, committee chairman, committee members and others the past year has brought increased recognition of the importance of agricultural engineering. It can now be said that agricultural engineering is established and that this Society is recognized as the logical clearing house for this particular field of knowledge.

Increasing recognition brings increased responsibilities. Our field is broad. We touch farm operations and farm life at many points. In fact the whole farm situation is so saturated with engineering applications that it is impossible to give a comprehensive treatment of our agricultural problems without dwelling at length upon this subject. The future looks bright for this organization. The opportunity for service is ours. Past accomplishments furnish the best evidence that the obligations which come with opportunity will be met.

There is not time to review in detail the work of the past year. In fact, with the Journal appearing every month, this is neither desirable nor necessary. However, there are a few outstanding developments to which I wish to call your attention.

The first of these is the formation of the Reclamation Section. Reclamation work has long been recognized as of national importance. Various organizations have been developed which devote their attentions to various phases of this field. These organizations have notable achievements to their credit, but so far as I am informed ours is the first technical society to accord official recognition to reclamation work as such. At present the Reclamation Section embraces the fields of land clearing, drainage, and irrigation. If there are any other lines which should be included they will be welcome if the case is properly presented.

The formation of the Reclamation Section will furnish a substantial stimulus to the more efficient utilization of our natural resources. We must not allow present conditions to blind us to the fact that this nation should develop every acre of land on which food can be economically produced. A large acreage of fertile land still awaits the magic touch of the drainage engineer. Desert areas are still dormant awaiting the irrigation water which will cause them to bloom and produce. The clearing of the cutover land in Wisconsin alone has been described by Dean H. L. Russel of the Wisconsin college of agriculture as a bigger undertaking than the digging of the Panama Canal. The organization of our Reclamation Section will form a clearing-house for information on these large problems and afford a rallying point for the men in this profession.

The College Section was also organized during the past year. This affords the agricultural engineering departments of the land grant colleges a point of organized contact with the work of the U. S. Department of Agriculture which has already resulted in giving coordination and stimulation to research and teaching work.

Agricultural engineering work, both in the U. S. Department of Agriculture and the land grant colleges, needs more substantial financial support then is now accorded to it. You have but to examine the financial reports of these institutions to realize the truth of this assertion. The organization of the College Section will afford another means of bringing this need to the attention of the public.

At present there are four distinct groups represented in the Society, viz., reclamation, college, farm buildings and farm operating equipment. The organization, of two of these groups into sections logically brings up the question of the desirability of organizing the two remaining groups into sections. It is my opinion that such action would be desirable but I gladly leave the final decision in this matter to the superior judgment of the members of the Society.

Our relations with other organizations have been most pleasant and profitable. These contacts promise to be of increasing importance.

We have had the honor of most substantial cooperation from the National Association of Farm Equipment Manufacturers, especially in standardization work. Members of a large number of firms represented in this organization have given freely of their time and counsel. The secretary, H. J. Sameit, has been ever ready to aid our work and offered many constructive suggestions. The organization has turned over a number of problems for solution, furnished financial support, and with the single injunction "find the facts." We are indeed fortunate in having this connection so firmly established.

The National Drainage Congress graciously recognized the work we are doing in the Reclamation Section and there are unmistakable evidences that our Society will be able to cooperate with this great organization to the benefit of both.

The officials of the American Farm Bureau Federation have on numerous occasions given voice to their belief in the desirability of standardization work. Just last month this organization took definite steps towards action in this direction and accorded this Society the honor of requesting it to be officially represented on a committee to further standardization work. It is an opportunity to get further action in a field where we are vitally interested.

Committee work must ever form the backbone of this organization. The officers are responsible for the appointment of committees and to a certain extent for the assignment of work to be done but these even cannot carry the load alone. Fortunately there is an increasing sense of the responsibility which a committee appointment carries on the part of our members. The point I especially wish to call to your attention is that there has not been developed a form of committee organization which has stood the test of subsequent developments. In organizing the committees for the past year your officers knowingly did some experimenting with meth-

*Delivered at the fifteenth annual meeting of the American Society of Agricultural Engineers, Chicago, December 27, 28, and 29, 1921.

ods of committee organization. The results have been gratifying. The problem has been whether to have a large number of independent committees or to appoint a general chairman for a certain field and have him develop and direct a number of subcommittees. The experience to date indicates that fewer major committees with the required number of subcommittees produces better results. However, there are cases where work is retarded by this method because of the roundabout course required to get action. It is a problem which will be solved in time but on account of its vital relation to Society progress I felt that the members should be fully informed of the situation.

Your president would feel that he had been remiss in regard to his duties if he did not take advantage of this opportunity to discuss very briefly future possibilities. In the midst of the stress of readjustment the future looks bright for agricultural engineering. Close students of agricultural development are unanimously agreed that we have passed the pioneer stage and are now entering the business stage of farming. Profits can no longer be taken largely from the increase in the value of the land but must be realized from farm operations. Can we as agricultural engineers visualize what this means?

In the future more attention will be paid to costs of production. In this program farm machines and the more efficient use of power will play a leading part. It is a situation made to order for the engineer.

Along with this business development in agriculture there is certain to come a demand for better living conditions on the farm. Farm buildings of the future will not simply be built; they will be designed and erected with a view to utility and beauty. They will contain modern equipment, with the farm home brought up to date. Here is another great opportunity for the agricultural engineer.

While there is much debate today as to whether we have an overproduction of foodstuffs at home or an underconsumption abroad the reclamation engineer, whether engaged in irrigation, drainage, or land clearing work, can continue serenely on his way firm in the belief that the day is coming when this foresight will be recognized as having been fundamental to our national development. He is adding new wealth in the form of potential food production.

So let us strive to be constructive in our work, serving present needs in an efficient manner and building for the future on a firm basis with a confidence and enthusiasm in keeping with the great field of agricultural engineering. Let us so labor that future generations may rise up and call us blessed.

Osage Orange Fence Posts

INVESTIGATIONS of the Ohio agricultural experiment station show that osage orange for fence posts is in a class by itself so far as long life is concerned. For example, in one fence forty years old it was found that one hundred per cent of the osage orange posts were sound.

Black locust is next in durability followed by red cedar. Fences were found in which eighty to ninety per cent of the posts made from locust were sound after twenty to thirty years of service.

Mulberry, catalpa, white cedar, chestnut, oak, black ash follow in order. Tamarack, a soft wood coming from Michigan has about the same value as white oak.

Investigation of a number of fences of concrete posts shows ten to thirty per cent disintegration in eight to fifteen years. The newer types of steel posts have not been in use long enough to determine their relative durability as compared with wood and concrete posts.

A. J. R. CURTIS

Our New President

A. J. R. Curtis elected president of the American Society of Agricultural Engineers for the year 1922 is recognized as one of the best informed engineers on farm buildings in the country. Mr. Curtis became a member of the Society early in its history and has since given considerable of his time and thought to its interests. The Society is indeed fortunate in having a man of Mr. Curtis' caliber as the chief executive for the coming year.

Mr. Curtis was graduated from Lewis Institute, Chicago, in 1909 and since that time has been engaged chiefly in educational and promotional work principally along farm-buildings lines. During the war he held the position of inspector of all Government concrete schools. At the present time he holds the position of manager of the cement products bureau of the Portland Cement Association in Chicago.

Mr. Curtis is entering on his new duties with the same enthusiasm, aggressivenes, and ability that characterize his activities in other directions.

Our new president will be able to give a good account of his administration and report substantial progress in the accomplishments of the Society at the end of the year only as the committees and the membership as a whole lend their support to the program which he, together with the council, has laid out. The future is big with possibilities for the advancement of the science and practice of agricultural engineering. This means unlimited opportunity for growth and service to the American Society of Agricultural Engineers, and therefore to each individual member of the Society. No one appreciates these possibilities more than Mr. Curtis, and no one is more determined than he that the Society shall develop them to the ultimate benefit of agriculture and the common good.

A. S. A. E. and Related Activities

The Fifteenth Annual Meeting

THE fifteenth annual meeting of the American Society of Agricultural Engineers held in Chicago, December 27, 28, and 29, 1921, marked another important mile post in the growth and activity of this Society and the advancement of the science of agricultural engineering. The older any scientific or technical society becomes, the more technical do its deliberations become. This was a noticeable, and a significant feature of the meeting. Papers, discussions, and reports dealing with agricultural engineering of a general and of a nontechnical or semitechnical character have given way to highly technical, more specific discussions. It is an advance that A. S. A. E. members can well be proud of, as well as one which offers big possibilities for future agricultural development and for general social and industrial improvements at large.

From the inspirational address of President E. A. White at the opening session to the brief remarks of the incoming president, A. J. R. Curtis, at the closing session of the third day, intense interest was shown in the various papers presented and discussed, and, though the hours of each session were really longer than should be, a remarkable interest and attendance was maintained throughout the entire time. Never before has the Society put on a program so full of interest to those in attendance and which represented such a valuable contribution to agricultural-engineering knowledge as at this meeting. The Meetings Committee deserves a great deal of credit not only for the variety of subjects discussed, but also for the ability and recognized standing of the speakers and the quality of the material they presented.

If there is one criticism that could be made of the program it is that it was too long to permit of full discussion of all the papers. This observation is particularly significant in that it shows not only progress in agricultural-engineering development and the increasing activities of this Society, but that the time has come when there is a real vital need for additional professional meetings of the Society and its sections to cover the ground that seems desirable and necessary.

Now that it has been decided to organize two professional sections in addition to and along the same line as the Reclamation Section, to cover all the professional activities of the Society, the thought was expressed by many prominent members during the last annual meeting that meetings of these sections could well be held during the year for presenting and discussing problems of interest and timely importance peculiar to those sections, leaving the annual meeting to give attention to matters of more general interest to all agricultural engineers and for the particular purpose of promoting agricultural engineering science in a big broad way. At this writing it is quite probable that the Reclamation Section, for example, will hold a professional meeting during Reclamation Week which is being arranged for by reclamation interests to be held in Kansas City some time next fall. It seems impracticable to have the annual meeting of the Society last longer than three days, therefore, the particular advantage of separate meetings of the professional sections will give engineers particularly interested in those sections the advantage of closer social and professional contact with men in their own line of work and enable them to devote more time to the presentation and discussion of problems that are of special interest to them.

The first day's session of the annual meeting was devoted to the reclamation program. The program as carried out was substantially the same as that published in the December number of AGRICULTURAL ENGINEERING, with two exceptions; Arthur E. Morgan who was scheduled to present the paper "Flood Control in Agriculture" was unable to fill his engagement, but his place on the program was very satisfactorily filled by O. N. Floyd of the staff of the Morgan Engineering Company, who was division engineer actively in charge of the flood control work which has been so effectively accomplished by the Morgan Engineering Company in the Miami Conservancy District. Dr. Elwood Mead, who was scheduled to present the paper entitled "The Advantage of a Planned Rural Development," could not be in attendance; however, his very interesting paper was presented at the meeting.

A great deal of interest was shown in the activities of the Reclamation Section and a great deal was accomplished in the way of organization and discussion of technical reclamation problems in the special session of the Reclamation Section which was held during the forenoon of the second day. In view of the short time this section has been organized, remarkable progress has been made. A great many reclamation engineers who have not become affiliated with the Society are investigating the possibilities offered by this, the only strictly technical organization of reclamation engineers.

The College Section organized at the annual meeting of the Society a year ago is also making excellent progress, particularly in the direction of coordination and cooperation, not only between the agricultural engineering departments of the various land grant colleges, but also between those departments and the agricultural engineering division of the U. S. Department of Agriculture. The organization of this section has provided a point of contact for these interests which is proving highly beneficial to agricultural-engineering development, and too much cannot be said in praise of the effort already made in this direction and what it means for the future of agricultural engineering. Prof. Davidson's paper, "The Organization of the College Section and Its Future Possibilities," not only struck a keynote but proposes a program for the future activities of the section which is comprehensive and which meets with the approval of the men interested in this particular line of work. There is a big field of activities for the College Section in promoting the interests of this Society and after sitting through the College Section program on the evening of the first day the writer gained the impression that with the ability of the men who are chiefly responsible for the progress that has been made so far and the will to make the work of this section an outstanding feature in A. S. A. E. activities, this section is bound to make good progress.

The farm structures program occupied the entire second day of the meeting, the program being the same as published in the Journal last month. During the past two or three years farm structures have been an important feature of the program of our annual meetings, but this year the farm structures section of the Meetings Committee outdid itself in the program which was provided. Particular and special credit is due to W. G. Kaiser for arranging this phase of the program, which was so productive of valuable farm structures material. It was Prof. J. B. Davidson who first said it,

that this Society has in its Transactions the most complete and valuable library of agricultural-engineering information in existence, and the farm structures program this year constitutes a large additional contribution to technical literature on farm structures.

One of the features of the banquet this year held the evening of the second day was the honoring of the honorary members recently elected. These were Joseph Doty Oliver, president of the Oliver Chilled Plow Works, and son of James Oliver, inventor of the Oliver plow, and John Barton Bartholomew, president of the Avery Company. Due to illness Mr. Oliver unfortunately could not attend the banquet, but a great deal of interest was shown in the talk by Mr. Bartholomew on what engineering is doing for agriculture, particularly in the application of the mechanical-power idea to farming operations. Mr. Bartholomew is well qualified to speak with authority on this subject inasmuch as he is not only a successful manufacturer of power-farming equipment, but owns and operates, largely with mechanical power, Yalehurst Farm near Peoria, Illinois.

One of the treats of not only the banquet but of the entire meeting was the presence of Dean Mortimer E. Cooley, dean of engineering at the University of Michigan, and recently elected president of the Federated American Engineering Societies to succeed Herbert Hoover. Dean Cooley's address at the banquet was confined to a presentation of the organization, purposes, and accomplishments of the Federated American Engineering Societies, which was listened to with a great deal of interest and enthusiasm by the members of the Society present. The following day the Society voted to continue its affiliation with the F. A. E. S., which had been tentatively withdrawn by the Council as a measure of economy pending further action by the Society.

The Society was particularly fortunate in having an opportunity to hear and discuss with Dean Cooley the opportunity which presents itself to this Society in affiliation with the F. A. E. S. The members of the Society will be interested to know that since the annual meeting the American Engineering Council, the executive or governing body of the F. A. E. S., unanimously voted to foster the study of the elimination of waste in agriculture proposed by the Society to Dean Cooley during his presence at the annual meeting. Incidentally, this offers one of the biggest opportunities ever available to this Society to promote the cause of agricultural engineering.

President E. A. White and president-elect A. J. R. Curtis also addressed the banquet briefly, and as usual both had an interesting and important message. Also it is not too much to say that the real entertainment of the evening, aside from the serious talks of the speakers mentioned. was none other than the canny toastmaster, Prof. William Aitkenhead, head of the department of agricultural engineering at Purdue University. This Society prides itself on having practically all of the outstanding agricultural engineers on its membership rolls, but until Prof. Aitkenhead's performance as toastmaster we have never had much to boast about in that line.

The farm power and equipment program on the third day was, like the rest of the program, particularly conspicuous as an unusually valuable contribution to agricultural-engineering knowledge. That section of the Society has been conspicuous for the contribution of a great amount of valuable information on various phases of farm power and equipment. and the farm power and equipment session of the annual meeting this year was no exception to the rule. In fact, at no previous meeting has there been so much material of permanent engineering value as at the meeting just past. The work which the Society is doing covers the investigations of various kinds of farm equipment, particularly the left-hand plow and disk-harrow investigations, so that the Society is filling an important need in securing scientific data, which is so much needed in the farm-equipment industry, and which this Society is in a particularly advantageous position to procure. The third day program not only pointed out an opportunity to the Society, particularly to the farm power and equipment section of its membership, but also a responsibility not only to the farm-equipment industry but to the farmer as well. A great many problems involving design, construction, operation, economics, etc., of farm equipment are awaiting solution by agricultural engineers. The responsibility of solving these problems lies at the door of the agricultural engineer and the opportunity both from the standpoint of the individual and this organization lies at the door of the American Society of Agricultural Engineers. Those who attended the farm power and equipment session were not only impressed with some of the problems that remain to be worked out, but were inspired with new enthusiasm to tackle the job.

Following the farm power and equipment program on the third day a short business meeting of the Society was held, the question of where the next annual meeting of the Society should be held being the chief topic of discussion. This discussion was followed by the meeting going on record as favoring St. Louis as the next meeting place and a recommendation was made to that effect. An amendment to the Constitution was proposed providing that a vote be taken at each annual meeting shall decide where the next annual meeting shall be held. It was voted to recommend this amendment for consideration by the Council.

Council Meeting

THE 1922 Council of the Society held its first meeting on the evening of December 29, at the close of the fifteenth annual meeting. Those members of the Council attending were President A. J. R. Curtis, J. B. Davidson, E. A. White, F. N. G. Kranich, F. A. Wirt, David Weeks, and Frank P. Hanson.

The publication of the 1920 and 1921 A. S. A. E. Transactions was discussed at some length, resulting in the Secretary being requested to provide estimates of cost, the decision as to when the Transactions should be published being deferred to a later date or until it was possible to get a better idea of the financial status of the Society during the coming year.

The discussion of the procedure to enroll county agents as extension affiliate members of the Society in the various states resulted in the Secretary being directed to act as manager of this campaign and carry it out as originally planned.

The organization of the Reclamation Section of the Society has proven so satisfactory that the Council has decided that it is desirable at this time to organize the other groups into sections. There was some discussion as to whether or not farm sanitation should be separated from farm structures. It was finally decided that for the present sanitation should be included with the farm structures section. A farm power and operating equipment section will also be organized, to which farm lighting will go, while all other phases of farm sanitation will come within the farm structures section. The purpose is to appoint a strong man as chairman of these sections who will be responsible for the section's activities and results.

It was decided that a study of cost, etc., of data sheets should be started at once, with a view to making available important agricultural-engineering data and information, of which this Society has a large amount.

The Council also took action to approve the change in the Reclamation Section constitution requested by that section following its special session on the second day of the annual meeting.

The Council elected Raymond Olney to serve as Secretary of the Society during the year 1922.